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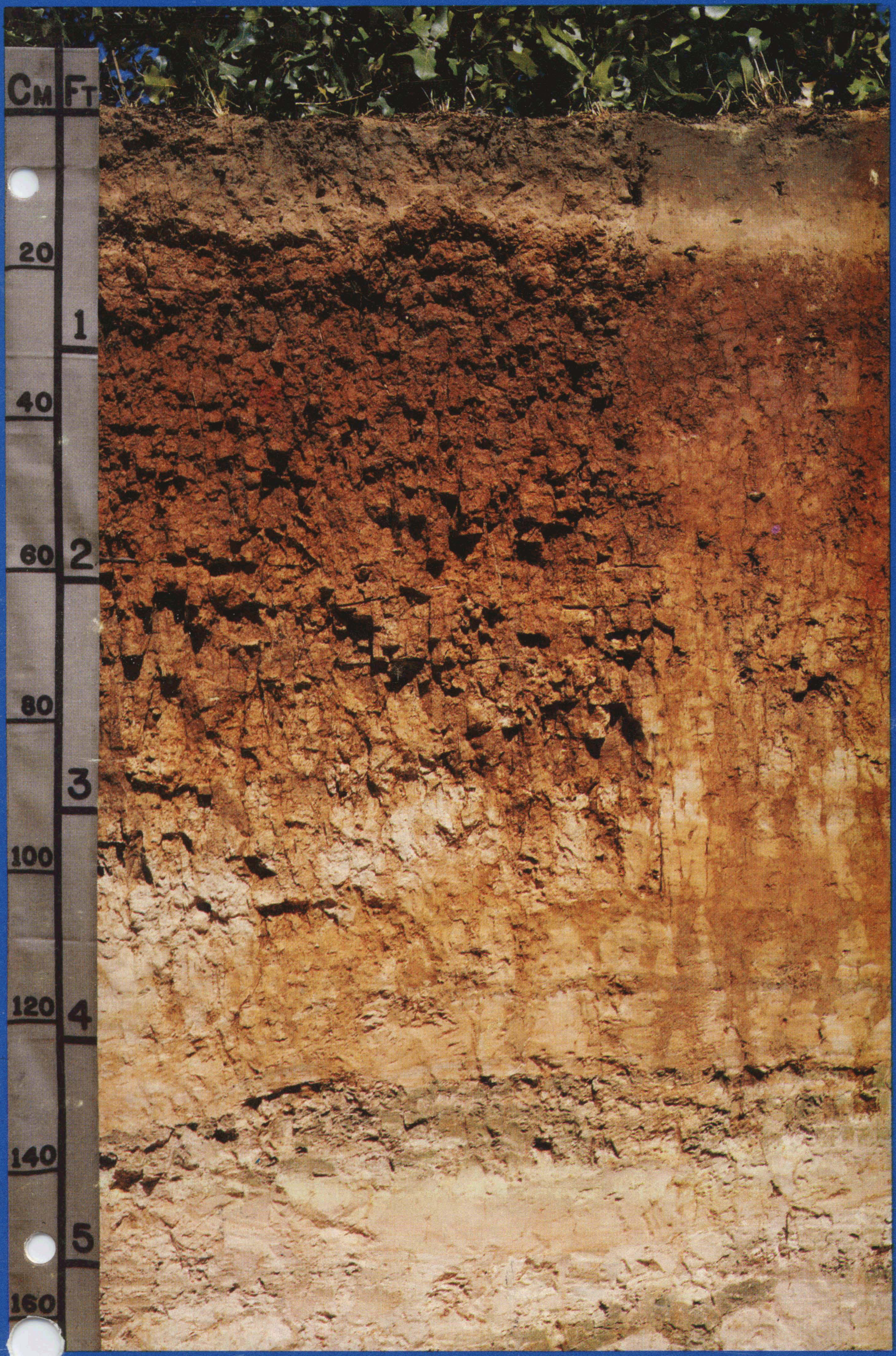
Soils and Climate . . .



Of the Texas A&M University Research and Extension Center at Stephenville in Relation to the Cross Timbers Land Resource Area

Profile of Windthorst Fine Sandy Loam

A1	0-4 inches
A2	4-7
B21t	7-17
B22t	17-26
B3	26-42
Cr1	42-50
Cr2	50-55

TEXAS A&M UNIVERSITY
TEXAS AGRICULTURAL EXPERIMENT STATION
NEVILLE CLARKE, DIRECTOR, COLLEGE STATION, TEXAS

Contents

Summary

The Texas A&M Research and Extension Center at Stephenville consists of approximately 650 acres. Most of this acreage is Windthorst or closely related soils. These soils are extensive in the western portion of the Cross Timbers land resource area. Other soils are included in station research through cooperative arrangements with area farmers.

Soils of the Cross Timbers are reasonably similar with respect to several important properties. Textures in the surface horizons generally range from fine sand to fine sandy loam, unless the soils are severely eroded. Their subsoil horizons are generally sandy clay loam, sandy clay, or clay. The soils differ markedly in the surface horizon thickness and, to some degree, in internal drainage. The soil reaction generally ranges from slightly acid to neutral in surface horizons.

Research is conducted on various phases of the production of peanuts, horticultural crops — principally peaches and pecans, and forages. The research efforts have been varied and include studies on soil management practices, development of new crop varieties, and control of insect and disease problems in plants.

The provision of adequate moisture and fertility are prominent among soil management needs. Irrigation has become a common practice in the area in recent years. Both sprinkler and trickle systems are used. Fertility needs vary with the crop. Nonlegumes generally respond well to nitrogen. Fertilization with phosphorus and potassium is recommended, but deficiencies of these elements generally are not as limiting as those of nitrogen. Occasional responses have been observed to iron and/or zinc.

The objective of research at the center is to develop programs that will contribute to a profitable agriculture in the Cross Timbers. This objective is pursued with a varied program that takes into account the many factors affecting plant production.

Soils and Climate...

Of the Texas A&M University Research and Extension Center at Stephenville in Relation to the Cross Timbers Land Resource Area

C. R. Stahnke, C. L. Godfrey, Joe Moore, and J. S. Newman*

Introduction

The Texas A&M University Research and Extension Center at Stephenville is located in Erath County approximately two miles north of Stephenville on Hwy. 281. The center consists of three tracts of land located in close proximity and totaling about 650 acres. Research programs are concentrated in the various aspects of the production of peanuts, peaches, pecans, and forages. An appreciable amount of research is conducted in cooperation with area farmers in order to include a wider range of environmental conditions than would be possible if all research were confined to the center. The center primarily serves the western portion of the Cross Timbers land resource area. This area was formerly classified as the West Cross Timbers, but it and the area previously classified as the East Cross Timbers have been combined into a single land resource area called the Cross Timbers. This discussion will be confined entirely to the western portion of the Cross Timbers.

Approximately 3,000,000 acres of the Cross Timbers are served by the center. The location of the area is indicated in Figure 1. Other land resource areas are commonly intermixed with the Cross Timbers. For example, the Cross Timbers and the Grand Prairie commonly occur in close association in Erath County. The intermingling of different land resource areas is of agricultural significance since farming units in these areas often consist of markedly different soils occurring in close association.

Gently to strongly sloping soils comprise most of the Cross Timbers. Slope and the dominantly sandy texture of the surface horizons make both wind and water erosion significant management problems. Techniques commonly used to combat these problems include terracing and the planting of cover crops in the season when the soil would normally be bare.

The agriculture of the area is diverse. Peanuts are the most important agronomic crop. Livestock production, including dairying in some counties, is of major importance. Other examples of agricultural enterprises in the area are the production of nursery stock, fruit crops, and vegetable crops. None of the latter group of enterprises currently rival peanuts and livestock production in economic importance.

General Description of the Area

Geology

Both Cretaceous and Pennsylvanian age strata occur in the general geographic area occupied by the western portion of the Cross Timbers (12). However, the major soils of this area have formed from Cretaceous materials. Atlee (2) stated that outcrops of the Paluxy and Trinity sands comprise the "West Cross Timbers." Both are Cretaceous deposits (2, 11). Atlee noted that the Paluxy formation thickens to the north and merges with Trinity sand in Wise County to form a single rock unit, the Antlers sand.

A comparison of four recent soil survey reports (6, 8, 9, 15) with the Abilene Sheet of the Geologic Atlas of Texas (1) indicates that soils of the Cross Timbers have formed over several Cretaceous formations. These formations and their major area of occurrence in the four county area are (1) the Paluxy in much of Erath and in southern Comanche Counties, (2) the Twin Mountains in much of northern Comanche County and in small areas of northern Erath, southeastern Eastland and western Parker Counties, and (3) the Antlers Sand in much of Eastland County. The latter is an extensive formation in Cross Timbers counties to the west of Eastland and Comanche (1) It has also been recognized in the northern counties of the Cross Timbers (2). All of these formations, though variable, are generally sandy.

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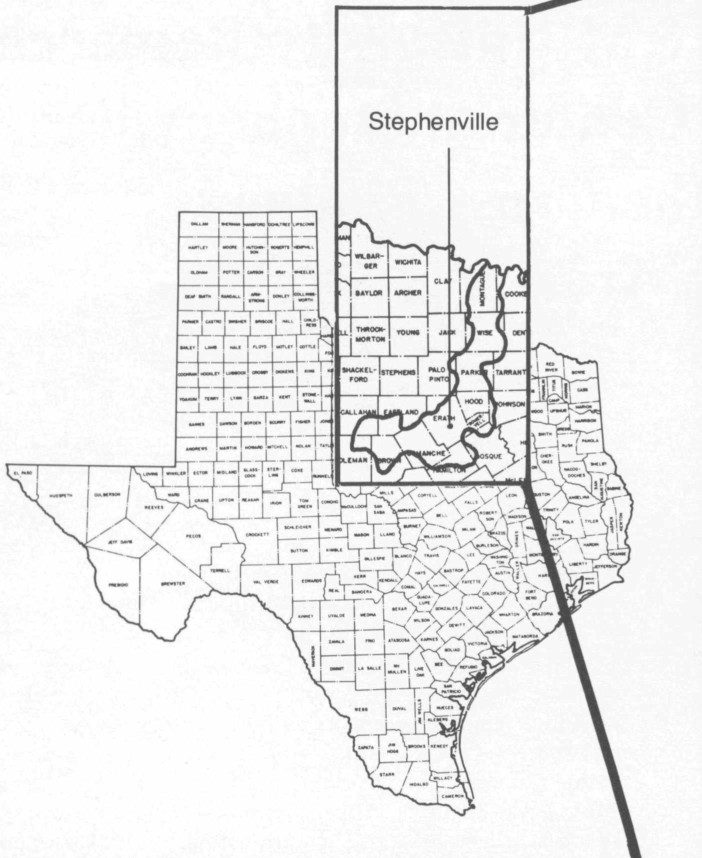

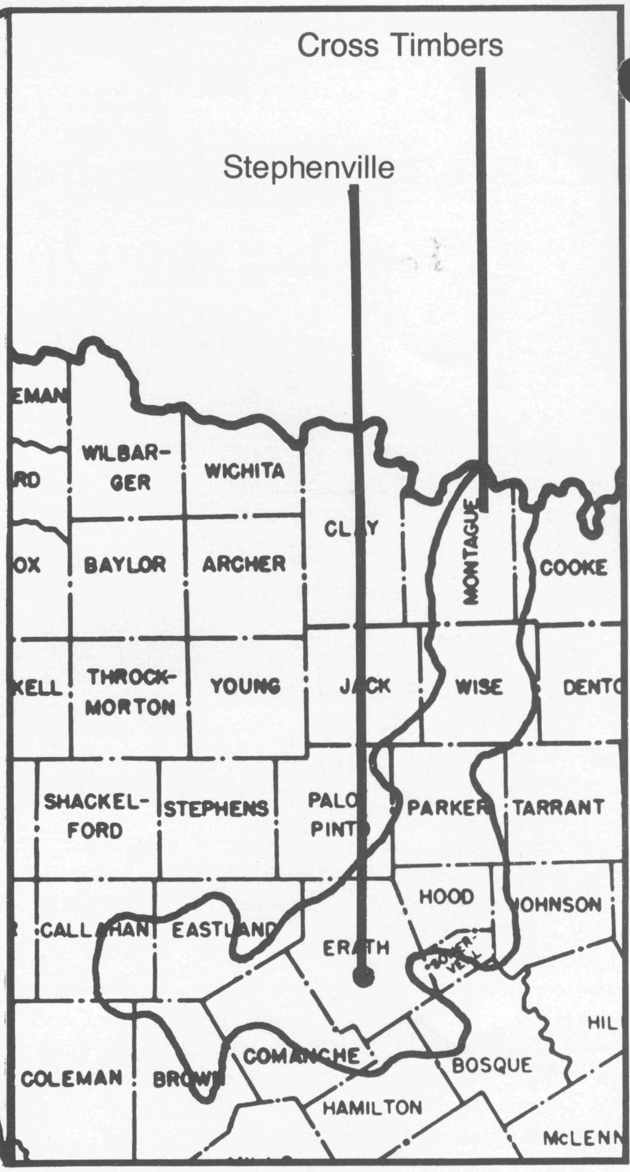

Figure 1. Principal geographic area served by the Texas A&M University Reserach and Extension Center at Stephenville.

A study relating geology to soils was done by Brown in Bosque County (4). Formations in the study area are the Edwards limestone, Comanche Peak limestone, Walnut clay, and Paluxy sand of the Fredericksburg group and the Glen Rose limestone of the Trinity group. Soils typical of the Cross Timbers were observed in the Paluxy sand, and soils typical of the Grand Prairie were observed in the other formations. Brown indicated that the dominant soils in the Paluxy sand were members of the Windthorst, Stephenville and Nimrod series. Soils identified as members of the Stephenville series at the time would currently be classified into other series, e.g. the Duffau or Weatherford.

Several formations in the Cross Timbers range from minor to major importance as aquifers. Sellards, *et al.* (12) reported artesian water reservoirs in the Trinity sands, the Glen Rose, the Paluxy and to a lesser extent in overlying formations. Sellards presumably was referring to the basal formation of the Trinity group in his mention of Trinity sands since he also considered the Paluxy to be a member of that group. Brown (4) reported that the principal aquifers in his study area were the Paluxy sand and the basal sands of the Trinity group. He indicated that the principal subsurface aquifers penetrated by deep wells are the basal Trinity sands. This true of many, probably most, wells currently used for irrigation.

Climate

The rainfall pattern in the Cross Timbers is erratic and presents serious problems to dryland agriculture. This problem can be more readily understood by considering climatic data gathered at the center in the 1942-1975 period.

Rainfall statistics are given in Table 1 and Figure 2. It is apparent that it is difficult to use rainfall records as a basis for making meaningful predictions. For example, periods of the year in which rainfall is generally high may be dry in a given year.

Precipitation probability estimates made by Griffiths and Orton (7) are of value in making long-term predictions regarding rainfall. Their predictions cover all of Texas and are based on data from 47 climatological stations. They note that their data, presented in the form of isoprobability lines, are subject to error. Precipitation probability estimates for Erath County, based on the previously mentioned data, are presented in Table 2.

These estimates were obtained by either selecting

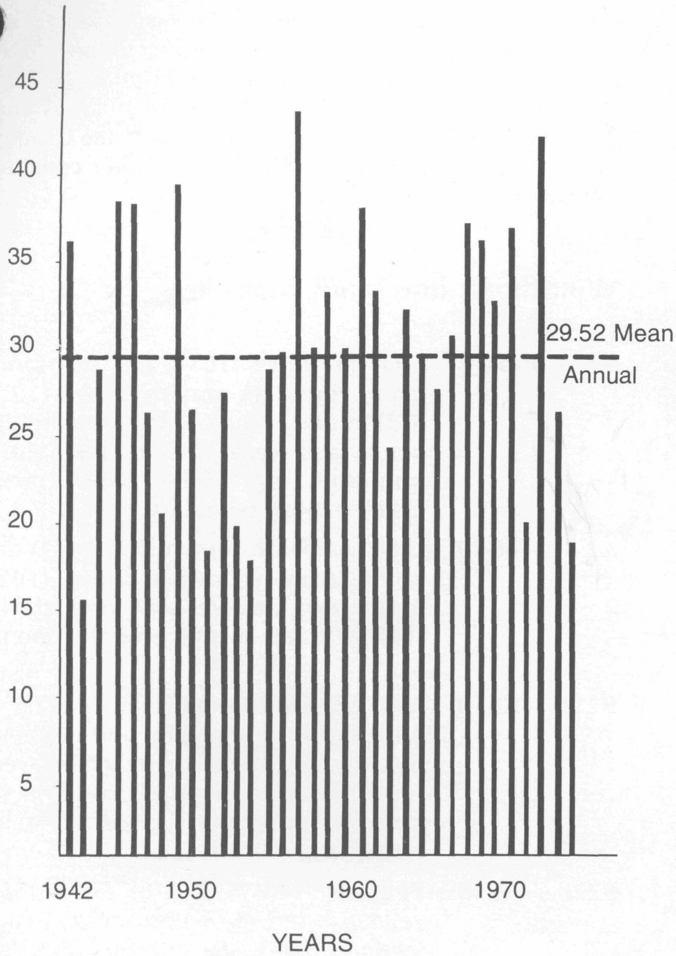

Figure 2. Annual rainfall at the center (1942-1975).

TABLE 1. PRECIPITATION STATISTICS FOR THE CENTER — 1942-1975.

Period	Average Inches	Range Inches
January	1.71	0.05 - 6.33
February	1.76	0.00 - 4.99
March	1.63	T* - 5.23
April	3.41	0.71 - 10.06
May	4.63	0.68 - 12.46
June	2.47	T* - 5.74
July	2.43	0.27 - 6.27
August	1.94	T* - 5.90
September	2.99	0.00 - 8.11
October	3.22	0.00 - 10.49
November	1.76	0.00 - 5.16
December	1.53	T* - 3.88
Annual	29.52	15.54 - 43.16

T* - Trace

the isoprobability line most closely approaching or, when possible, passing through Erath County and considering the probability value for this line as being applicable to Erath County. This procedure undoubtedly increased error present in the original estimates. However, the probability estimates obtained should be reasonably valid for Erath County. Precipitation in other parts of the area served by the center would probably vary slightly.

The temperature ranged from −2° to 110° F during the 1942-1975 period. The average annual temperature was 64.2° F and the monthly average ranged from 44.0° F in January to 82.9° F in July. Monthly values for average daily minimum and maximum temperatures ranged from 32.3° F in January to 94.7° F in August. Temperatures below 32° F were recorded on an average of 48 days annually. Average dates of the last killing frost in the spring and the first in the fall are March 23 and November 15, respectively. The average length of the growing season is 237 days.

Soils

General Description

The soils occurring in the geographic area of interest may be divided into several broad groups according to the general characteristics of the parent material. One group has formed predominantly from sandstone, or closely related materials. These soils are representative of the Cross Timbers. Examples of other soils are those formed from limestone, or other highly carbonatic materials, and alluvial deposits. The latter soils commonly occur in close association with those formed from sandstone and are sometimes important agriculturally. However, they are not generally representative of the area served by the center. Small acreages of the alluvial soils are utilized similarly to the typical soils of the Cross Timbers.

The properties of the soils composing the Cross Timbers are significantly influenced by the soil forming factors topography and parent material. The soils commonly range from nearly level to gently sloping. A few areas are sloping. The parent materials, while tending to be sandy, have a variable particle size composition. Also, the sandstones are occasionally interstratified with carbonatic materials. The net result of the variability in these factors is significant variability between soils and commonly the occurrence of soils in a complex pattern. For example, deep noncalcareous soils are sometimes found in close association with apparently similar soils having a carbonatic horizon in the profile.

Within limits, it is possible to generalize regarding the properties of most important Cross Timbers soils. The A horizons usually have textures ranging from fine sand to loamy fine sand and fine sandy loam, but the latter two textural classes are the most common. The A horizon thicknesses are quite variable and are sometimes the basis for differentiation between certain series. The B horizon textures generally range from sandy clay loam to sandy clay or clay and are commonly the basis for differentiation between series. Regarding color, the B horizons have reddish hues, generally 2.5YR or 5YR. Some of the B horizons contain grayish mottles, or in some pedons, a grayish matrix. These mottles are indicative of less well drained conditions and are considered in the classification of the soils. The profiles of most soils are deep and the morphological properties are similar. There are some differences in structure, color, and thickness of certain horizons.

The properties of soils of the Cross Timbers may be better appreciated by considering their classification and detailed descriptions of some of the major soils. The classification of a number of soils according to the USDA system (13) is given in Table 3. Descriptions of the typifying pedons of two of the major soils, Chaney and Windthorst, follow. The typifying pedons of the Chaney and Windthorst soils are in Erath and Parker counties respectively.

Chaney loamy sand[1]

Horizon

A1----------0-4"--Dark grayish-brown (10YR 4/2) loamy sand, very dark grayish brown (10YR 3/2) moist; weak granular structure; slightly hard, friable; few, fine, rounded, quartz pebbles; medium acid; clear, smooth boundary.

A2--------4-14"--Light-gray (10YR 7/2) loamy sand, grayish brown (10YR 5/2) moist; structureless, single grain; slightly hard, very friable; few, rounded, quartz pebbles; medium acid; abrupt, wavy boundary.

B21t----14-22"--Dark-red (2.5YR 3/6) sandy clay; dark red (2.5YR 3/6) moist, with common, fine, distinct, pale-brown and light brownish-gray mottles; weak, medium, blocky structure; very hard, very firm; few, fine, chert fragments; medium acid; clear, smooth boundary.

B22t----22-34"--Mottled-red (2.5 YR 4/6), light yellowish-brown (10YR 6/4) and light brownish-gray (10YR 6/2) sandy clay; weak; blocky structure; very hard, very firm; few, fine, chert fragments; medium acid; gradual, smooth boundary.

B3 ------34-40"--Brownish-yellow (10YR 6/6) sandy clay loam, yellowish brown (10YR 5/6) moist, with common, medium, distinct red, pale-brown, and light brownish-gray mottles; weak, blocky structure; very hard, firm; medium acid; gradual, smooth boundary.

C1 ------40-52"--Light brownish-gray (2.5Y 6/2) clay loam, light brownish gray (2.5Y 6/2) moist, with a few, fine, faint olive-yellow mottles; massive; medium acid; gradual, wavy boundary.

IIC2 ----52-72"--Olive-gray (5Y 5/2) shaly clay; common soft masses of white material; slightly acid.

Windthorst fine sandy loam[1]

Horizon

A1----------0-4"--Grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, fine, subangular blocky and weak, fine, granular structure; soft, very friable; slightly acid; clear, smooth boundary.

A2--------4-10"--Light yellowish-brown (10YR 6/4) fine sandy loam, yellowish brown (10YR 5/4) moist; massive; soft, very friable; slightly acid; abrupt, smooth boundary.

B21t----10-18"--Red (2.5YR 4/6) sandy clay, red (2.5YR 4/6) moist; strong, fine and medium, blocky structure; extremely hard, very firm; nearly continuous clay films on faces of most peds; medium acid; gradual, smooth boundary.

B22t----18-38"--Yellowish-red (5YR 5/6) sandy clay, yellowish red (5YR 4/6) moist; many, medium, faint, strong-brown mottles; many, distinct, brownish-yellow mottles; moderate, coarse, blocky structure; extremely hard, very firm; common discontinuous clay films on faces of peds; medium acid; gradual, wavy boundary.

B3t -----38-50"--Coarsely and prominently mottled-red (2.5YR 4/8), yellowish-brown (10YR 5/8), and pale-brown (10YR 6/3) sandy clay loam; thin lenses and pockets of sandy loam; weak, coarse, blocky structure; extremely hard, very firm; slightly acid; gradual, wavy boundary.

C--------50-60"--Light-gray clay with prominent coarse mottles of red and yellow; massive; slightly acid.

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[1]Colors are for dry soil unless otherwise stated.

Map Symbol	Soil Name
BcC	Bolar clay loam, 3-5% slopes
Bo	Bosque loam, occasionally flooded
Bu	Bunyan fine sandy loam, occasionally flooded
DfB	Duffau fine sandy loam 1-3% slopes
HaA	Hassee fine sandy loam, 0-1% slopes
HaB	Hassee fine sandy loam, 1-3% slopes
WoB	Windthorst fine sandy loam, 1-3% slopes
WoB2	Windthorst fine sandy loam, 1-3% slopes, eroded
WoC	Windthorst fine sandy loam, 3-5% slopes
WsC2	Windthorst soils, 3-5% slopes, eroded
WsD3	Windthorst soils, 1-8% slopes, severely eroded
WvB	Windthorst Variant fine sandy loam, 1-3% slopes

Figure 3. Soils of the Texas A&M University Research and Extension Center at Stephenville.

TABLE 2. PROBABILITY ESTIMATES OF RECEIVING A MINIMUM AMOUNT OF PRECIPITATION PER MONTH IN ERATH COUNTY.*

	Minimum Precipitation, Inches										
Month	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0
	Probability										
January	0.80	0.60	0.50	0.40	0.30	0.20	0.10	0.10	0.10	0.05	0.01
February	0.90	0.70	0.60	0.40	0.30	0.20	0.20	0.10	0.10	0.05	0.05
March	0.90	0.70	0.50	0.40	0.30	0.20	0.10	0.10	0.05	0.05	0.05
April	0.95	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.20	0.10
May	0.99	0.99	0.95	0.90	0.80	0.70	0.70	0.60	0.50	0.40	0.30
June	0.90	0.70	0.60	0.50	0.40	0.40	0.30	0.20	0.20	0.20	0.10
July	0.80	0.60	0.50	0.40	0.30	0.20	0.20	0.10	0.10	0.05	0.05
August	0.70	0.60	0.40	0.30	0.20	0.20	0.10	0.10	0.10	0.05	0.05
September	0.80	0.70	0.60	0.50	0.40	0.30	0.30	0.20	0.20	0.20	0.10
October	0.80	0.80	0.60	0.50	0.40	0.30	0.30	0.20	0.20	0.20	0.10
November	0.80	0.60	0.40	0.30	0.30	0.20	0.10	0.10	0.05	0.05	0.01
December	0.80	0.70	0.50	0.40	0.30	0.20	0.10	0.10	0.10	0.05	0.05

*Compiled by extrapolating data presented in the form of precipitation isoprobability lines.

TABLE 3. CLASSIFICATION OF SELECTED SOILS (SOIL SURVEY STAFF, JANUARY 1970) OF THE CROSS TIMBERS.

Soil Series	Order	Suborder	Great Group	Subgroup	Family
Arenosa	Entisols	Psamments	Quartzipsamments	Typic Quartzipsamments	Thermic, coated
Chaney	Alfisols	Ustalfs	Paleustalfs	Aquic Paleustalfs	Fine, mixed, thermic
Cisco	Alfisols	Ustalfs	Haplustalfs	Udic Haplustalfs	Fine loamy, siliceous, thermic
Demona	Alfisols	Ustalfs	Paleustalfs	Aquic Arenic Paleustalfs	Clayey, mixed, thermic
Duffau	Alfisols	Ustalfs	Paleustalfs	Udic Paleustalfs	Fine loamy, siliceous, thermic
Nimrod	Alfisols	Ustalfs	Paleustalfs	Aquic Arenic Paleustalfs	Loamy, siliceous, thermic
Patilo	Alfisols	Ustalfs	Paleustalfs	Grossarenic Paleustalfs	Loamy, siliceous, thermic
Pedernales	Alfisols	Ustalfs	Paleustalfs	Udic Paleustalfs	Fine, mixed, thermic
Selden	Alfisols	Ustalfs	Paleustalfs	Aquic Paleustalfs	Fine loamy, siliceous, thermic
Weatherford	Alfisols	Ustalfs	Haplustalfs	Ultic Haplustalfs	Fine loamy, siliceous, thermic
Windthorst	Alfisols	Ustalfs	Paleustalfs	Udic Paleustalfs	Fine, mixed, thermic

Reasonably good concepts of several Cross Timbers soils can be obtained by comparing them to soils of the Chaney and Windthorst series. Some of the more important soil properties that may be used in this comparison are given for selected series in Table 4. The comparisons can be facilitated by also considering the classification of the soils at the subgroup level (Table 3).

Inspection of the information in Table 4 indicates certain differences between the soils. For example, the Chaney and Demona soils are similar except for the A horizon thickness. The Duffau, Nimrod, and Selden soils differ from the Chaney soil with respect to the B horizon texture; they differ from each other with regard to either the A horizon thickness or drainage class. Solum thickness of the various soils, though differing to some extent, is generally difficult to use as a differentiating criteria.

Chaney and Windthorst soils appear to be almost identical if only the information in Table 4 is considered. However, grayish mottles occur in the upper part of the B horizon of the Chaney but not the Windthorst soil. These mottles, which suggest some degree of drainage problems in the Chaney, are taken into account in classification at the subgroup level (Table 3). The Pedernales series differs from the Chaney and Windthorst soils with respect to the drainage class. Also, the Pedernales is the only one of these three soils with a calcic horizon. A calcic horizon has an accumulation of calcium or calcium and magnesium carbonate. The carbonate content, expressed as $CaCO_3$ equivalent, equals or exceeds 15% and generally is at least 5% greater than the carbonate content of an underlying horizon.

Concepts of other series of the Cross Timbers can probably be best obtained by slightly different comparisons or considerations than those previously used. Cisco and Weatherford soils, while similar to Duffau with respect to several important characteristics, differ with regard to solum thickness (Table 4). Specifically, carbonates occur within the 40-60 inch depth in the Cisco series and sandstone occurs within this depth in the Weatherford series. The Duffau solum extends to a depth greater than 60 inches.

Two of the soils listed in Table 3, Arenosa and Patilo, can best be described independently of other series. The Arenosa soils have a thin sandy A horizon overlying a sandy C horizon, which extends to a depth greater than 80 inches. The Patilo soils have sandy A horizons greater than 40 inches in thickness that overlie sandy clay loam B horizons at depths less than 80 inches. The B horizon must be sufficiently thick to classify as an argillic horizon. The argillic is a subsurface horizon containing accumulations of clay. Generally, the clay con-

TABLE 4. PROPERTIES OF SELECTED CROSS TIMBERS SOILS.

Series	A horizon Thickness	B horizon Texture[1]	Solum Thickness	Drainage Class
Chaney	20″ or Less	SC or C	30-50″	Moderately Well
Demona	20-40″	SC or C	50-90″	Moderately Well
Nimrod	20-40″	SCL	60-80″+	Moderately Well
Seldon	20″ or Less	SCL	54-80″+	Moderately Well
Duffau	20″ or Less	SCL	60″+	Well
Cisco	20″ or Less	SCL	40-60″	Well
Weatherford	20″ or Less	SCL	40-60″	Well
Pedernales	20″ or Less	SC or C	35-60″	Well
Windthorst	20″ or Less	SC or C	35-60″	Moderately Well

[1]SCL = sandy clay loam, SC = sandy clay, and C = clay. The abbreviations refer to the most clayey portion of the B horizon.

tent must be significantly higher than that of the overlying surface horizon.

Other soils are of importance in the Cross Timbers. However, those that have been discussed are representative of this land resource area.

Soils of the Center

A map of the soils of the Center is shown in Figure 3. Windthorst is the only soil of the Cross Timbers that is extensive on the Center. A variant of this soil was mapped in order to take a carbonatic horizon occurring at a relatively shallow depth into account. A small acreage of the Duffau series also occurs on the center. Other soils of the center are not representative of the Cross Timbers. Some of the other soils, for example Bunyan, are occasionally used similarly to soils such as the Windthorst and Duffau.

The map shown in Figure 3 is a detailed revision of a previous map. The purpose of increasing the detail of the soil map was to facilitate research planning at the center. Significant inclusions of other soils occur in the various mapping units, and additional on-site inspection of the soil will still be desirable for certain types of small plot research.

Physical and Chemical Properties

Soil survey investigations have provided physical, chemical, and mineralogical data on several soils of the Cross Timbers (14). Data on the Windthorst soil is given in Tables 5 and 6. It is hazardous to speculate as to how this particular pedon varies from the "typical" Windthorst. However, unpublished analyses indicate that it is slightly atypical in two respects: (1) the clay content in the subsoil is higher than average, and (2) the pH of the surface horizon is somewhat higher than average. Data on other soils (5, 14) indicate that soils of the Cross Timbers are generally similar chemically except for differences associated with the clay content, e.g. the tendency for the cation exchange capacity to increase with clay content. The different soils vary physically in ways previously noted (Table 4). With relatively minor exceptions, the mineralogical data for the Windthorst soil is similar to that reported for a limited number of related soils (14).

A recent study of Murthy, *et al.* (10) on a number of Texas soils provides mineralogical and chemical data on the A horizons of the Windthorst and "Stephenville" series. The latter soil would now be classified into another series. The clay fractions were found to consist primarily of interstratified mica and montmorillonite. Some vermiculite, occurring in interstratified mixtures with the previously mentioned minerals, and kaolinite also were observed. The study suggested that the micas in both the clay fraction and the coarser fractions are important sources of potassium (K) to plants. The results were interpreted to mean that most of the soils in the study, the "Stephenville" being one possible exception, do not need K fertilization except when the demand for available K is unusually large.

Soils of the Cross Timbers are reasonably similar chemically. Their pH is generally near neutral, but the pH in some is sufficiently acid to require liming. The acid conditions have been created in some cases by fertilization of these weakly buffered soils with ammonium fertilizers. Deficiencies of all macronutrients, particularly nitrogen, are observed. There also have been some observations of iron and zinc deficiencies.

Soil Utilization

Soil Management for Crop Production

Soil management requirements vary somewhat with the crop, but several problems are usually present. Common soil management problems in the Cross Timbers are erosion control, fertility maintenance, and the provision of adequate moisture.

The rolling topography of the area and the generally sandy surface texture of the soils make them subject to both wind and water erosion. Terracing is a common practice used to minimize water erosion. The practice is not feasible for some soils because a deep, sandy surface horizon makes it difficult to construct stable terraces. Fortunately, water erosion generally is not a serious problem on soils with these characteristics. Cover crops, consisting of plants such as rye and winter peas, are commonly used during noncropping seasons to control both wind and water erosion. Strip cropping is used on a limited basis as a wind erosion control practice.

Drought is a major limiting factor for crop production in the Cross Timbers. Irrigation is commonly used to solve the problem. Water is applied primarily by sprinkler systems. Research is being conducted on trickle irrigation, and the system appears to offer excellent promise for orchard crops such as peaches and pecans. With the possible exception of peanuts, the larger percentage of most crops is still produced under dryland conditions where the drought problem can only be minimized by suitable cultural practices. These involve a combination of soil and crop management practices.

Fertility needs vary considerably with the crop. The soils are deficient in nitrogen, and most non-legumes respond well to its addition. Responses to phosphorous and potassium are not as evident as the responses to nitrogen. However, it is considered desirable to occa-

TABLE 5. PHYSICAL AND CHEMICAL DATA OF A WINDTHORST LOAMY FINE SAND.

Horizon	Depth Inches	Particle Size Classes, Percent[1] Sand	Silt	Clay	VFS	FS	MS	CS	VCS
Ap	0-10	81.3	12.5	6.1	9.9	65.5	3.6	1.9	0.4
B21t	10-18	36.1	8.6	55.4	6.2	26.8	1.8	1.0	0.2
B22t	18-25	39.9	13.1	47.0	6.3	30.2	1.7	1.4	0.3
B23t	25-39	46.3	19.1	34.6	8.7	34.4	1.6	1.5	0.2
B3	39-47	28.9	39.3	31.8	25.1	3.3	0.1	0.2	0.0
C1	47-58	30.8	36.9	32.3					
C2	58-64	21.5	40.1	38.4					
IIC3	64-70	93.0	3.3	3.7	2.5	90.1	0.2	0.2	0.0

Horizon	Depth Inches	Extractable Bases, Meqs./100 Grams of Soil Ca	Mg	Na	K	CEC[2]	% Base Saturation	pH, 1:1 H_2O	% Organic Carbon
Ap	0-10	3.5	0.4	0.1	0.4	4.0	100	7.7	0.2
B21t	10-18	17.0	5.2	0.2	1.0	27.7	84	6.9	0.8
B22t	18-25	13.1	5.6	0.2	0.8	24.7	80	6.3	0.4
B23t	25-39	10.4	4.9	0.2	0.6	19.6	82	6.1	0.2
B3	39-47	9.0	4.6	0.3	0.6	17.5	83	5.9	0.2
C1	47-58	11.0	5.3	0.3	0.7	20.4	85	6.3	0.2
C2	58-64	12.7	6.7	0.3	0.8	23.9	86	6.4	0.2
IIC3	64-70	1.3	0.5	0.1	0.1	2.3	87	7.0	0.1

[1]VFS = very fine sand, FS = fine sand, MS = medium sand, CS = coarse sand, and VCS = very coarse sand.

[2]CEC = Cation Exchange Capacity

TABLE 6. MINERALOGICAL DATA OF A WINDTHORST LOAMY FINE SAND.

Horizon	Depth Inches	Sand 2-0.05 mm	Silt 0.05-0.002 mm	Coarse Clay 0.002-0.0002 mm	Fine Clay <0.0002 mm
Ap	0-10	Q1	Q1 K3 M3 F3	M2 K2 Q3	MV1 M3 K3
B21t	10-18	Q1 F3	Q1 K2 M2 F3	M1 K2 Q3	MV1 M3 K3
B22t	18-25	Q1 F3	Q1 K2 M2 F3	M1 MV2 K2 Q3	MV1 M3 K3
B23t	25-39	Q1 F3	Q2 K2 M2 F3	M1 MT2 K2 Q3	MT1 M3 K3
B3	39-47	Q1 F3	Q2 K2 M2 F3	M1 K2 MV2 Q3	MV1 M3 K3
C1	47-58	Q1 F3	Q2 K2 M2 F3	M1 K2 MV2 Q3	MV1 M3 K3
C2	58-64	Q1 F3	Q1 K2 M2 F3	M1 K2 MV2 Q3	MV1 M3 K3
IIC3	64-70	Q1 K3 F3	K1 M2 Q3 F3	M1 K1 MV3 Q3	MV1 M3 K3

Minerals:
F = Feldspar
K = Kaolinite
M = Mica or Illite
MT = Montmorillinite
MV = Diffuse, Hydrated, Expansible and Micaceous (13-18Å)
Q = Quartz

Estimated quantities of minerals:
Subscript 1 = >40%
Subscript 2 = 10-40%
Subscript 3 = <10%

sionally apply a complete fertilizer in order to maintain these nutrients at adequate levels in the soil. This is true even in peanut production where responses to fertilization have been erratic. There may also be a need for iron, for zinc, or both, under certain conditions that have not been well defined. Deficiencies are most likely to be observed on certain tree crops or ornamental shrubs. Pecans are a good example of a plant that responds to zinc. Zinc is applied as a foliar spray rather than to the soil.

Other soil management problems involve the control of weeds and soilborne plant pathogens. Weeds are controlled primarily by the use of herbicides. Control of plant pathogens is accomplished by various chemicals. Control of certain of these organisms can be facilitated by crop rotation. More effective methods of pest control are being researched.

Interpretations for Non-agricultural Land Uses

While the western portion of the Cross Timbers is not highly urbanized, there is an increasing need for soil interpretations for land uses other than commercial agriculture. Examples of the utilization of such interpretations include their application to engineering decisions in the development of home sites and to decisions regarding landscaping and the production of noncommercial orchards. Such interpretations are particularly applicable in this area since many home sites have been and are being developed on small acreages. This discussion will be general. Detailed information should be sought from other sources, including the soil conservation service and the county extension offices.

Interpretations for four types of land use are presented in Table 7 for selected soils of the Cross Timbers and closely associated soils of the Grand Prairie. The ratings for orchards are based on personal communications and will not necessarily correspond to other interpretative classifications. However, they will serve as useful guidelines in the selection of soils for orchards. The ratings of soils for lawns and gardens were derived by modifying criteria presented in an Oklahoma State University publication (3). Other ratings are taken from soil series interpretations compiled by the Soil Conservation Service (SCS), USDA. The terms in Table 7 should be regarded as having relative rather than absolute meanings. For example, a severe rating for septic systems does not mean that a soil cannot be used for that purpose. However, the problems to be overcome in making the septic system function satisfactorily would be significantly greater than for soils having slight or moderate limitations.

TABLE 7. LIMITATIONS AND POTENTIALS OF SELECTED SOILS FOR SELECTED LAND USES.

	Degree of Limitation		Potential	
	Type of Use			
Series	Dwellings	Septic Systems	Lawns and Gardens	Orchards
Chaney	Moderate	Severe	Fair	Fair
Denton	Severe	Severe	Fair	Poor
Duffau	Slight	Slight	Fair*	Good
Hassee	Severe	Severe	Poor	Poor
Nimrod	Slight	Severe	Fair	Fair
Pedernales	Moderate	Severe	Fair*	Fair
Purves	Severe	Severe	Poor	Poor
Selden	Slight	Severe	Fair*	Fair
Windthorst	Moderate	Severe	Fair*	Good

*This rating applies to soils having a surface texture coarser than sandy loam. The same soils having a sandy loam surface texture would have a rating of "good."

Inspection of Table 7 indicates that most of the soils will pose a problem in the development of home sites not serviced by a central sewer system. Several of the soils — Denton, Hassee, and Purves — have a high clay content at or near the surface and an accompanying high shrink-swell potential that may result in damage to dwellings. However, the most common problem is slow permeability in most of the soils that severely limits their suitability for septic systems. Most of the soils listed can be used for home site development provided the limitations are taken into account, but the difficulty of adequately handling the limitations varies with the soil. The Hassee and Purves soils, particularly the Hassee, are good examples of soils that have exceptionally serious limitations. A very slow permeability and commonly wet conditions create problems in the Hassee that generally are not feasible to overcome. The shallow depth and high clay content in the Purves, and similar soils, create problems that can be overcome only with considerable difficulty.

Fertility and water holding capacity are among the properties influencing a soils potential for lawns and gardens. Therefore, shallow and coarse textured soils were rated as either fair or poor, depending on the severity of the problem. The Hassee soil is deep and generally has a desirable texture in the surface horizon, but it was rated as poor because of drainage problems. As with interpretations previously discussed, an undesirable rating does not necessarily mean that a soil cannot be successfully used for a desired purpose. For example, a shallow soil will sometimes produce satisfactory yields of vegetables, but it would be less desirable as a garden than an otherwise comparable deep soil because there would be a higher requirement for irrigation.

Suitability of soils of the geographic area served by the center can be evaluated for use as orchard sites by considering depth and drainage. Specifically, it is desirable that the soils be deep and well drained. Soils of the Grand Prairie generally are not as deep as would be desirable and occasionally have drainage problems; therefore, they are generally not well suited to orchard crops. Most soils of the Cross Timbers have either a fair or good potential for orchards. Since most are deep, their ratings primarily reflect drainage differences. Fair and good ratings were generally applied to soils classed as moderately well and well drained respectively. An exception is the Windthorst soil. It was rated as good, even though it is considered to be a moderately well drained soil. However, the morphological evidence of drainage problems occurs relatively deep in the profile, and it is probably better drained than soils such as the Nimrod and Chaney, even though all are placed into the same drainage category.

Acknowledgments and Notes on Soil Surveys

The original soil survey of Erath County, published in 1923, was made by T. M. Bushnell of the Texas Agricultural Experiment Station and H. W. Hawker and D. B. Pratapas of the USDA. The center was surveyed in 1941 by E. H. Templin and A. L. Nabers. The soils were correlated in that year and amended in February, 1943.

The survey by Templin was revised in 1957 by Ralph Schwartz and Lemund Goerdel of the Soil Conservation Service. This survey was later updated by W. R. Elder and Jesse R. Thomas of the SCS. It was correlated in 1960 by Harvey Oakes, SCS, in consultation with Dr. C. L Godfrey of the Texas Agricultural Experiment Station and Elder and Thomas of the SCS. The modification of the 1941 survey was prompted in part by significant modification of some soil areas by terracing operations and by relatively serious erosion of some areas subsequent to the 1941 survey. There was also a desire to bring the survey more into accord with current soil surveys.

The current soil survey of Erath County was completed in 1965. The final correlation, prepared by Dr. Lindo J. Bartelli, Principal Soil Correlator, Soil Conservation Service, was approved June 16, 1966. The survey of the center was revised in 1972 by Dr. Clyde R. Stahnke of the Texas Agricultural Experiment Station and Joe Moore of the Soil Conservation Service. The purpose of the revision was to incorporate more detail into the survey, thus making it more suitable for plot work pl[illegible]n the center. The final field review and field [illegible]relations were held April 26, 1973 with Dr. C. L. Godfrey of the Texas Agricultural Experiment Station and Joe D. Moore and Billy J. Wagner of the Soil Conservation Service present. Additional land was acquired by the center and was mapped in the fall of 1974 by Joe Moore and Clyde Stahnke. The final field review was completed June 25, 1975 by Joe Moore and Billy J. Wagner. The correlation was approved by James R. Coover, Principal Soil Correlator, Soil Conservation Service, on October 2, 1975.

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